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PATENT
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NIGHT VISION GOGGLES TRAINING SYSTEM

BACKGROUND OF THE INVENTION

5 [001] This invention relates to a training system and method for implementing the system, and more particularly, a system and method for training aircrew pilots in the use of night vision goggles.

[002] The training of aircrew pilots in the use of night vision goggles (NVG) is typically conducted in a classroom setting through the use of
10 courseware and instructional videos, supplemented by ground-based training simulators. Training simulators equipped with NVG apparatus allow pilots to train in more realistic environments under task-loaded conditions. The available technology and associated costs limited the fidelity and application of such ground-based NVG simulation.

15 [003] There are two traditional technical approaches to NVG training in a simulator. The first is known as the stimulated approach, in which the pilot wears actual NVG flight hardware in the training simulator and the goggles are stimulated using a visual display system and digital image generator. The second approach is known as simulation, in which the pilot wears a head-mounted display (HMD) driven by an image generator and digital post
20 processing system.

[004] In the stimulated approach, infrared (IR) projectors (or sometimes just red CRTs and appropriate filters) are used to stimulate actual NVG. The projectors must have sufficient power and dynamic range to provide the full
25 range of irradiance at the entrance pupil of the NVG thus emulating actual environment radiant power reflecting diffusely off natural terrain under all

phases of the moon. Sufficient dynamic range is provided through a combination of video gray scale quantization and a separate projector dynamic gain control and optical filters to reproduce dark overcast night to full moon and clear night. For multi-screen display systems, this complex projector system
5 must be replicated for each screen. This approach does not however, provide sufficient irradiance to provide the additional dynamic range (on the order of 120 DB) needed to reproduce effects produced by the direct viewing of bright lights, explosions or flares, so some of these effects need to be simulated in the image generator. Furthermore, for high fidelity NVG terrain simulation it is necessary
10 that the image generator render the night scene using a physics based, radiometrically correct reflectance model based on a high fidelity lunar and atmospheric model.

[005] The display is viewed directly by the NVG through the green notch filter of the NVG in the same manner as in the aircraft. This provides a stable
15 image which is not displaced from the aircraft boresight by even slight head movements and does not appear to "swim" or "jitter" as it does when the image is produced on helmet, e.g., in a HMD system, by mixing this video with simulated NVG imagery. The image produced by NVG stimulation through the display projector is also significantly more stable than when simulated NVGs are
20 used. This is because the image is produced off the helmet, as it is in the real world.

[006] A further significant disadvantage of this approach is that the entire environment must be "light tight" to prevent spurious light from reaching the goggles.

25 [007] In the simulated approach, just as in the simulated approach, a high-fidelity physics-based, NVG terrain simulation image generator and database are used to render the night scene using a physics-based, radiometrically correct lunar and atmospheric reflectance model. The principal difference between the simulated and stimulated approaches is that in the
30 simulated approach actual NVGs are not used and the sensor effects are

simulated in a video post processor for display on helmet-mounted CRTs constructed to resemble NVGs. The video post processor computes the average intensity value of the scene in the instantaneous field of view. It then uses this data, along with the information on lunar and atmospheric conditions, to set gain and to inject the appropriate level of scintillation noise into the video signal provided to the simulated NVG display. The gain and noise level appropriate to the simulated nighttime scene are calibrated according to empirical data gathered by observation of actual NVG as used in the real world. Halos around intense light sources must be simulated in size and other qualitative effects in the image generator in the same manner as described for the simulated approach.

[008] The simulated NVG cannot view the direct or head up display (HUD) directly, so a simulated HUD model must be used to generate HUD video that is mixed with simulated NVG video for display on the simulated NVG display. This HUD presentation is subject to "swim", which may be distracting. Also, the use of helmet-mounted displays has never been widely accepted by the training community due to complex human factors issues.

SUMMARY OF THE INVENTION

[009] Accordingly, this invention relates to a training system for teaching the use of night vision goggles including a means for generating high fidelity, infrared, terrain simulation images, and means in communication with the image generation means for providing sufficient irradiance to increase the dynamic range needed to reproduce effects to simulate direct viewing of bright lights such as produced by explosions and flares, and more particularly to increase the dynamic range needed to reproduce effects to simulate direct viewing of bright lights.

[010] In another aspect of the present invention, a method for simulating night vision as seen through a pair of goggles comprises the steps of: a.

providing a pair of simulated goggles; b. generating a high fidelity, infrared, terrain simulation image viewable in the goggles; c. simulating the entire range of natural night time terrain irradiance, and d. scan converting the resultant image generated to video for display through the simulated goggles.

- 5 [011] This invention relates specifically to a training system and method in the use of night vision goggles with a proposed hybrid of the simulation and stimulation approaches, which eliminates the need for the complex post processing hardware/software required by the stimulation approach and the complex projection system required by the simulation approach. The present
- 10 approach is also unique in that it provides the full dynamic range of NVG simulation. The stimulation of actual NVG is performed off-helmet and the resulting image in the NVG eyepiece is scan-converted to video for on-helmet display on simulated goggles or projected on a display screen using an area of interest display system.
- 15 [012] Multiple IR CRTs with combining optics and appropriately weighted neutral density filters provide the stimulation. Each CRT is driven by successively higher order bytes of digital video so that up to 200 DB dynamic range of irradiance (10 x order of magnitude) is provided to an NVG image intensifier tube. The NVG and associated stimulation apparatus are packaged
- 20 in a "light tight" package with appropriate light baffles and optical coatings to limit light scatter so as to maintain contrast. This is possible because the higher intensity sources, which must be imaged onto the light intensifier, are typically point sources, which, although very intense, do not add excessive amounts of radiance to the light path. Halos, scintillation, noise and automatic gain control
- 25 (AGC) effects are produced in the goggle image intensifier and are 100% faithful to the NVG physics because actual NVGs are used. Each of three 12-bit video signals are allocated to the appropriate portion of the total irradiance range according to the scene elements which they represent, as follows:

- 30 Low Intensity: Natural terrain irradiance resulting from starlight, moonlight and other natural night sky irradiators

Medium Intensity: Distant and/or low intensity radiators such as aircraft lights, stars, moon, distant cultural lights

High Intensity: Close and/or high intensity radiators such as beacons, flares, missile firing, explosions

- 5 [013] The entire range of natural night-time terrain irradiance is assigned to one of the three video signals, the other two are used to represent the full range of natural and artificial radiators when directly viewed by NVG and for light reflected from intense artificial sources. The image generator allocates point radiators and extended area reflectors of especially powerful irradiators to
- 10 the proper video signal by a dynamic assignment process based on a computation of radiated power, distance from the simulated eyepoint and atmospheric attenuation. The output of the NVG image intensifier is scan converted by a high resolution 12 bit video camera to preserve its resolution and dynamic range.

15 BRIEF DESCRIPTION OF THE DRAWINGS

- [014] The SOLE Figure is a schematic, flow chart illustrating the night vision training system and method of the present invention.

20 DETAILED DESCRIPTION OF THE INVENTION

- [015] Referring now to the drawing in detail, the "NVG in a Box" 10, is worn by a pilot being trained. The NVG (night vision goggles) receive images generated by multiple IR (infrared) CRTs (computer radiated terrain images) with combining optics and appropriately weighted neutral density filters to provide stimulation. The stimulation of actual NVG is performed off-helmet and the resulting image in the NVG eyepiece is scan-converted to video for on-helmet display on simulated goggles. Alternatively, the display can be projected
- 25 on a screen using a high resolution projector.
- 30

[016] Each CRT 12 in the NVG apparatus 10 is driven by successively higher order bytes of digital video so that up to 200 DB dynamic range of irradiance (10 orders of magnitude) is provided to a NVG image intensifier tube 14. The NVG and associated stimulation apparatus 10 are packaged in a light tight package with appropriate light baffles and optical coatings to limit light scatter so as to maintain contrast. This is possible because the higher intensity sources, which must be imaged onto the light intensifier 14, are typically point sources, which, although very intense, do not add excessive amounts of radiance to the light path. Halos, scintillation, noise and AGC (Automatic gain control) effects are produced in the goggle image intensifier 14 and are 100% faithful to the NVG physics because actual NVG IG (image generator)/HUD (head-up display) graphics 16 from a NVG compatible database 18 are used and fed to apparatus 10.

[017] Each of three 12-bit video signals are allocated to the appropriate portion of the total irradiance range according to the scene elements which they represent, as indicated in the following table:

<u>Irradiance Range</u>	<u>Scene Element</u>
Low intensity	Natural terrain irradiance resulting from Starlight, moonlight and other natural night sky irradiators
Medium intensity	Distant and/or low intensity radiators such as aircraft light, stars, moon, distant cultural lights
High intensity	Close and/or high intensity radiators such as beacons, flares, missile firing, explosions

[018] The entire range of natural nighttime irradiance is assigned to one of the three video signals, which are fed from the host simulator 20 to the graphics generator 16; while the other two signals are used to represent the full range of natural and artificial radiators when directly viewed by NVG and for

light reflected from intense artificial sources. The image generator 16 allocates point radiators and extended area reflectors of especially powerful irradiators to the proper video signal by a dynamic assignment process based on a computation of radiated power, distance from the simulated eyepoint and atmospheric attenuation.

[019] The output of the image intensifier 14 is scan converted by a high resolution 12 bit video camera 22 to preserve its resolution and dynamic range. A head tracking system 24 is used to provide a signal to the IG graphics generator 16 sensing the head orientation of the pilot undergoing training for the proper orientation of IG line of sight. This provides a stable HUD (heads-up display) image which is not displaced from the aircraft boresight by even slight head movements and does not appear to "swim" or "jitter", since the signal generated is viewed directly by the NVG in the same manner as in the aircraft.

[020] It should be understood, of course, that the foregoing relates to preferred embodiments of the invention and that modifications may be made without departing from the spirit and scope of the invention as set forth in the following claims.